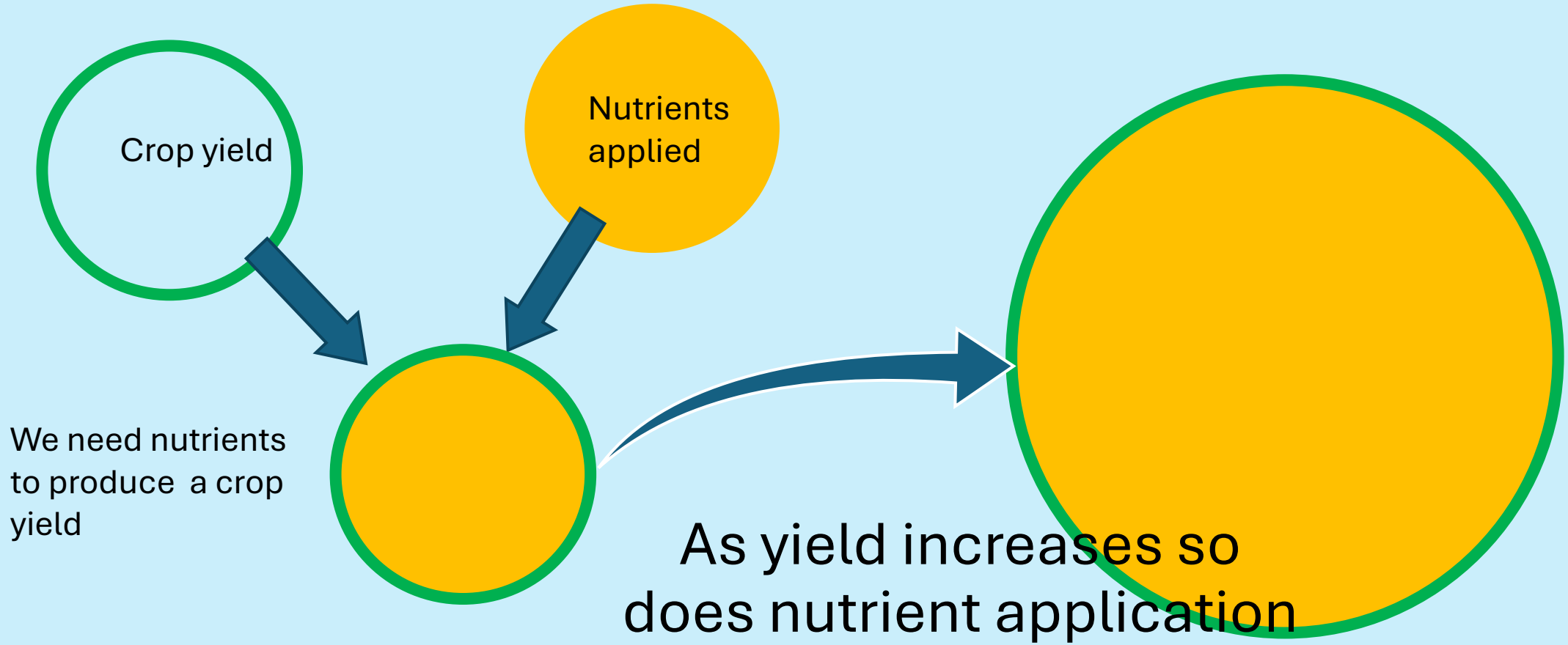
Crop Yield Trends

5/09/2025

Tom Butler, EPA

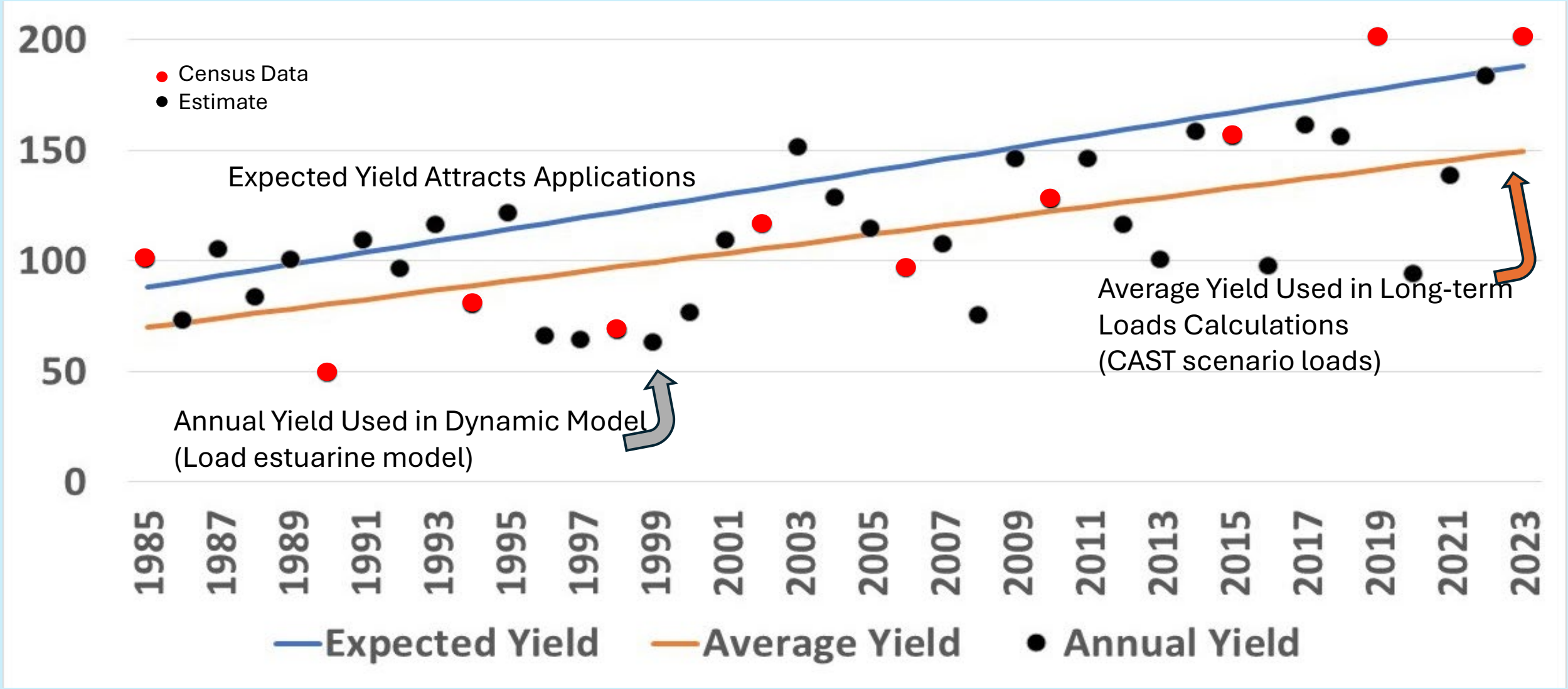
Why crop yields matter

- Yields and nutrient applications are tied together

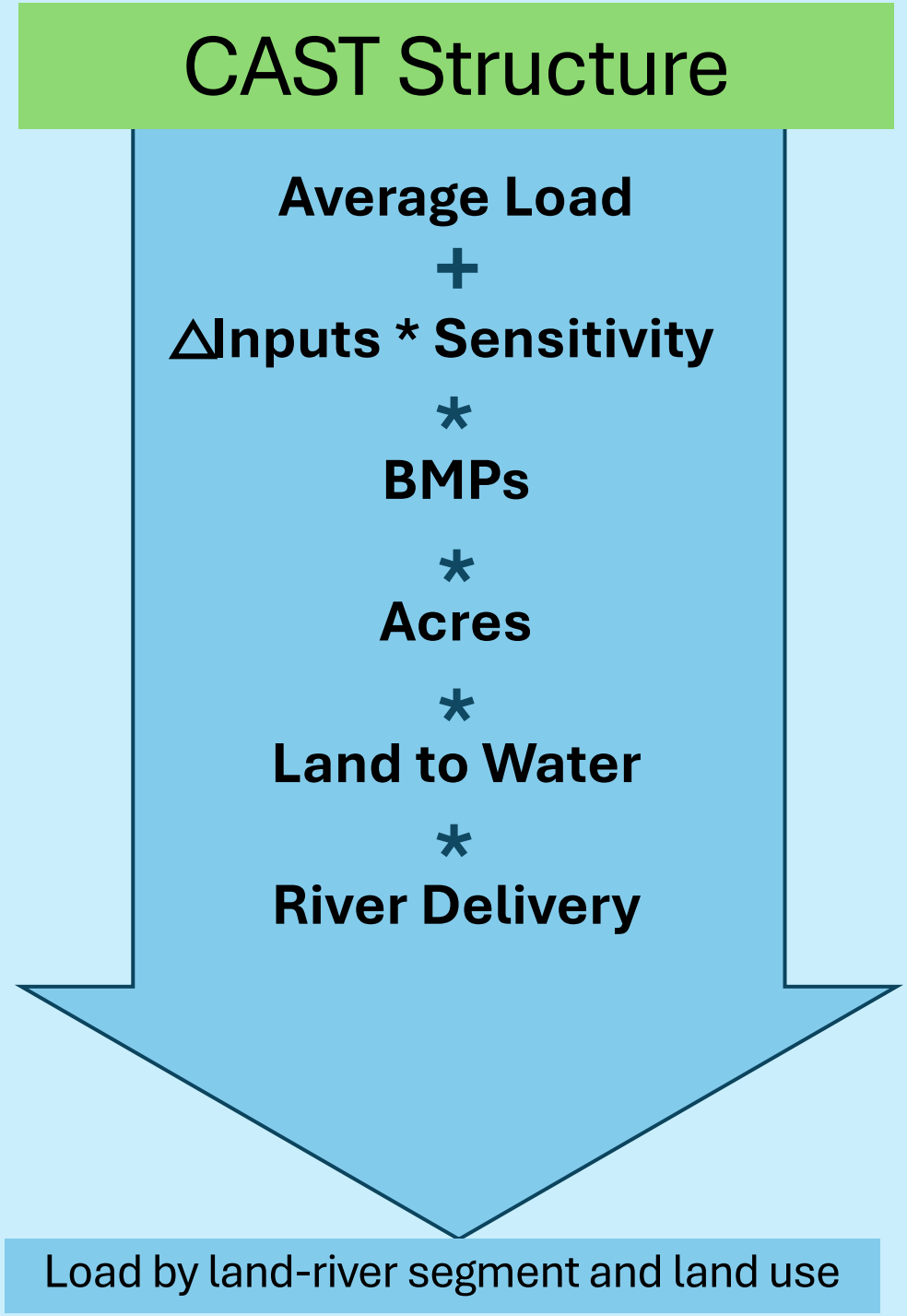


Models can be used to estimate the yield that attracts nutrient application, isolate the effects of management by accounting for weather

*EXAMPLE DATA ONLY



A quick refresh of how CAST works:



CAST Structure

Illustrative example

Average Load

+

ΔInputs * Sensitivity

*

BMPs

*

Acres

*

Land to Water

*

River Delivery

Average nitrogen load to stream for double cropped ag land watershed wide is 40 pounds per acre

Load by land-river segment and land use

CAST Structure

Average Load

+

ΔInputs * Sensitivity

*

BMPs

*

Acres

*

Land to Water

*

River Delivery

Load by land-river segment and land use

Illustrative example

FERTILIZER

Your area applies 115 pounds of fertilizer while the watershed-wide average is 140.

Each additional pound of fertilizer results in 0.2 lbs of runoff

(115-140) * 0.2 = -5 lbs/acre

CAST Structure

Average Load

+

ΔInputs * Sensitivity

*

BMPs

*

Acres

*

Land to Water

*

River Delivery

Load by land-river segment and land use

UPTAKE

Illustrative example

Your area uptakes 110 pounds of fertilizer while the watershed-wide average is 120.

Each additional pound of uptake results in -0.17 lbs of runoff

(110-120) *- 0.17 = 1.7 lbs/acre

CAST Structure

Average Load

+

ΔInputs * Sensitivity

*

BMPs

*

Acres

*

Land to Water

*

River Delivery

SUM each of the inputs* sensitivities for each input category (e.g. fertilizer, uptake, etc.) with the watershed average load

(-5)+(1.7)+(40) =36.7 lbs

Fertilizer

Uptake

Average Load

Load by land-river segment and land use

CAST Structure

Average Load

+

ΔInputs * Sensitivity

*

BMPs

*

Acres

*

Land to Water

*

River Delivery

Load by land-river segment and land use

BMPs are applied which give, in aggregate, a 20% reduction

36.7 * (1-.20) = 29.36 lbs/acre

CAST Structure

Illustrative example

Average Load

+

ΔInputs * Sensitivity

*****

BMPs

*****

Acres

*****

Land to Water

*****

River Delivery

There are 100 acres of double cropped land in this segment

29.36 lbs/acre * 100 acres = 2936 lbs

Load by land-river segment and land use

CAST Structure

Illustrative example

Average Load

+

ΔInputs * Sensitivity

*****

BMPs

*****

Acres

*****

Land to Water

*****

River Delivery

Load by land-river segment and land use

The land here is 50% leaker than average due to high groundwater recharge in the piedmont carbonate

The river system reduces loads by 30%

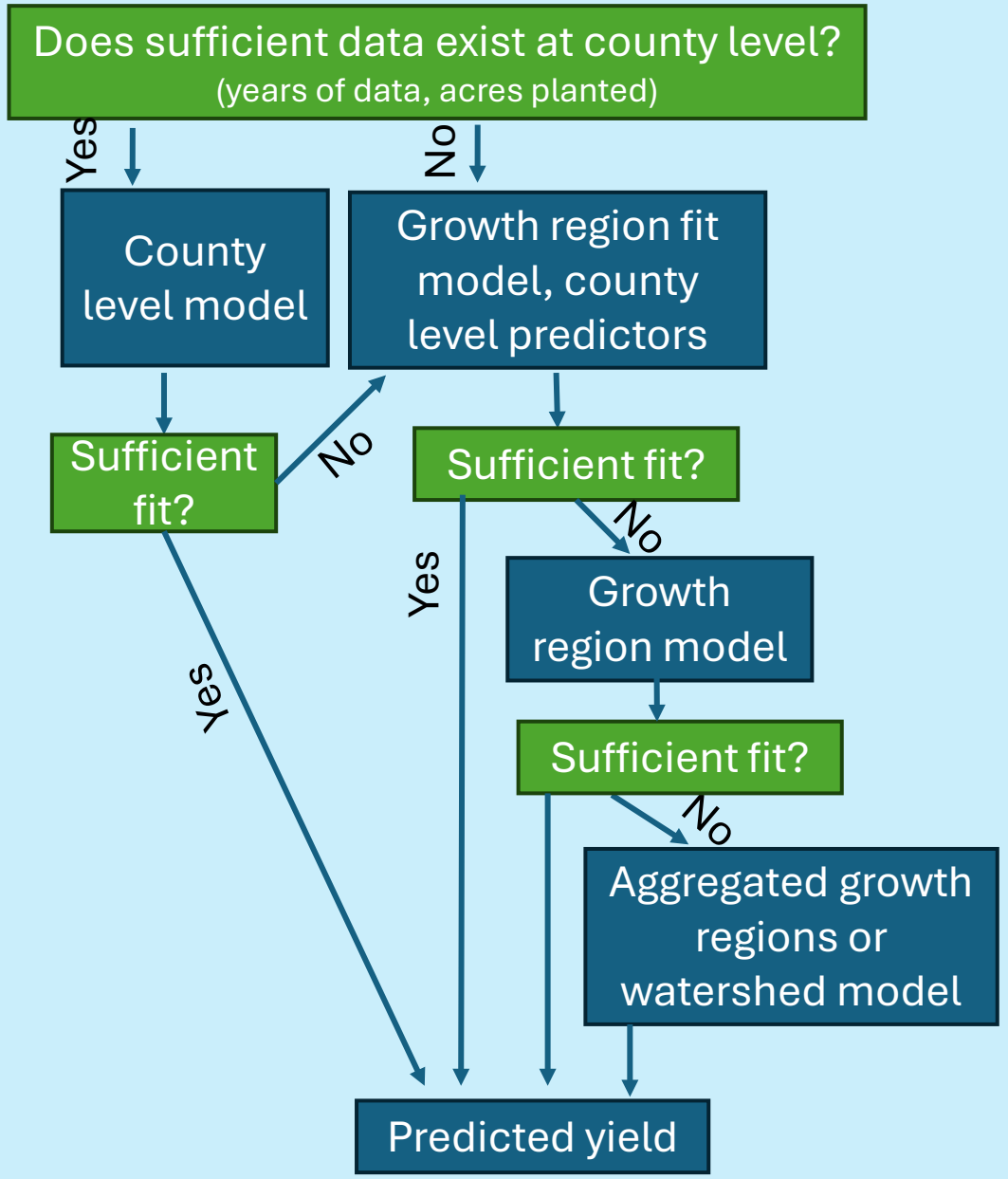
2936 lbs * 1.5 * (1-.30) = 3082.8 lbs Delivered to the Bay from this land use and segment

Issue were identified with P6 yields

- Often too low
- Didn’t not capture the trend (or muted trend)
- Often very variable from year to year

Modeling crop yields, proposed P7 approach

- A county level model is preferred, but there are a total of four models generated to predict yields based on available data and fit.

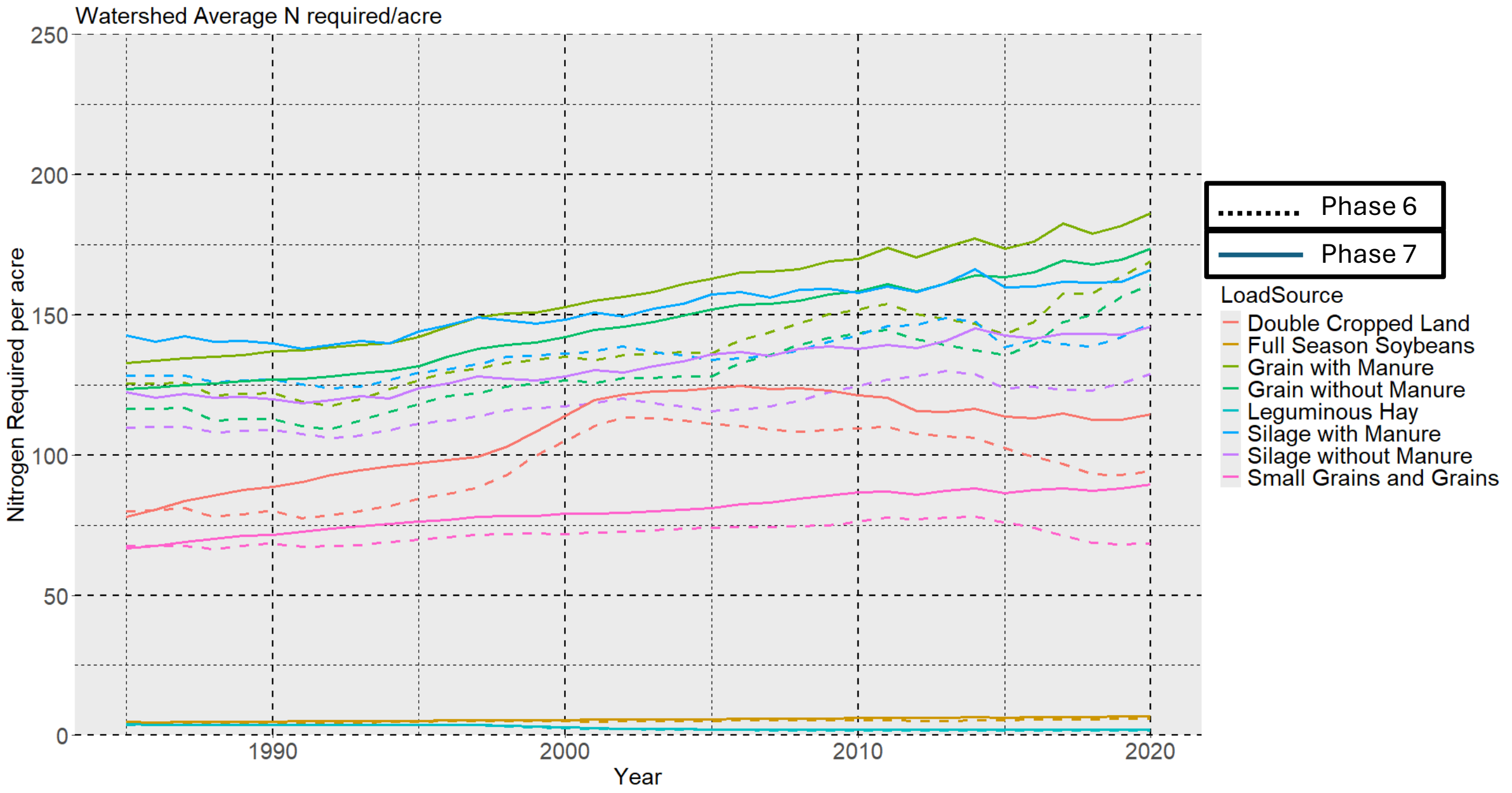


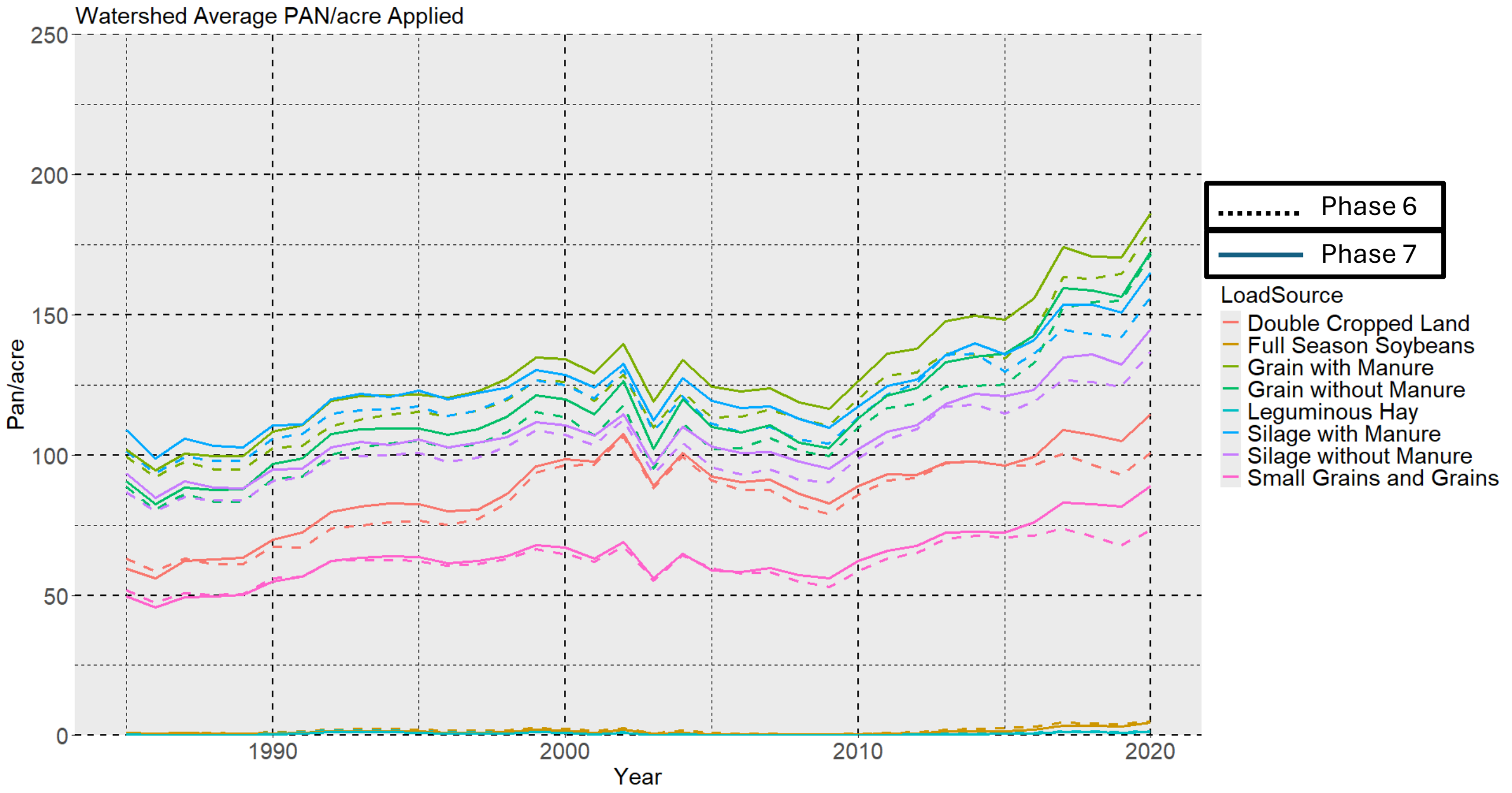
Model is fit to Census of Agriculture (COA) and Survey data

- This is a change in 2025
- COA and Survey are weighted based on estimate of uncertainty
- Generally, the Survey is weighted 20% of the COA
- Using both the weighted Census and Survey reduces the negative impact of any bad Census data without substantially decreasing model fit or consistency

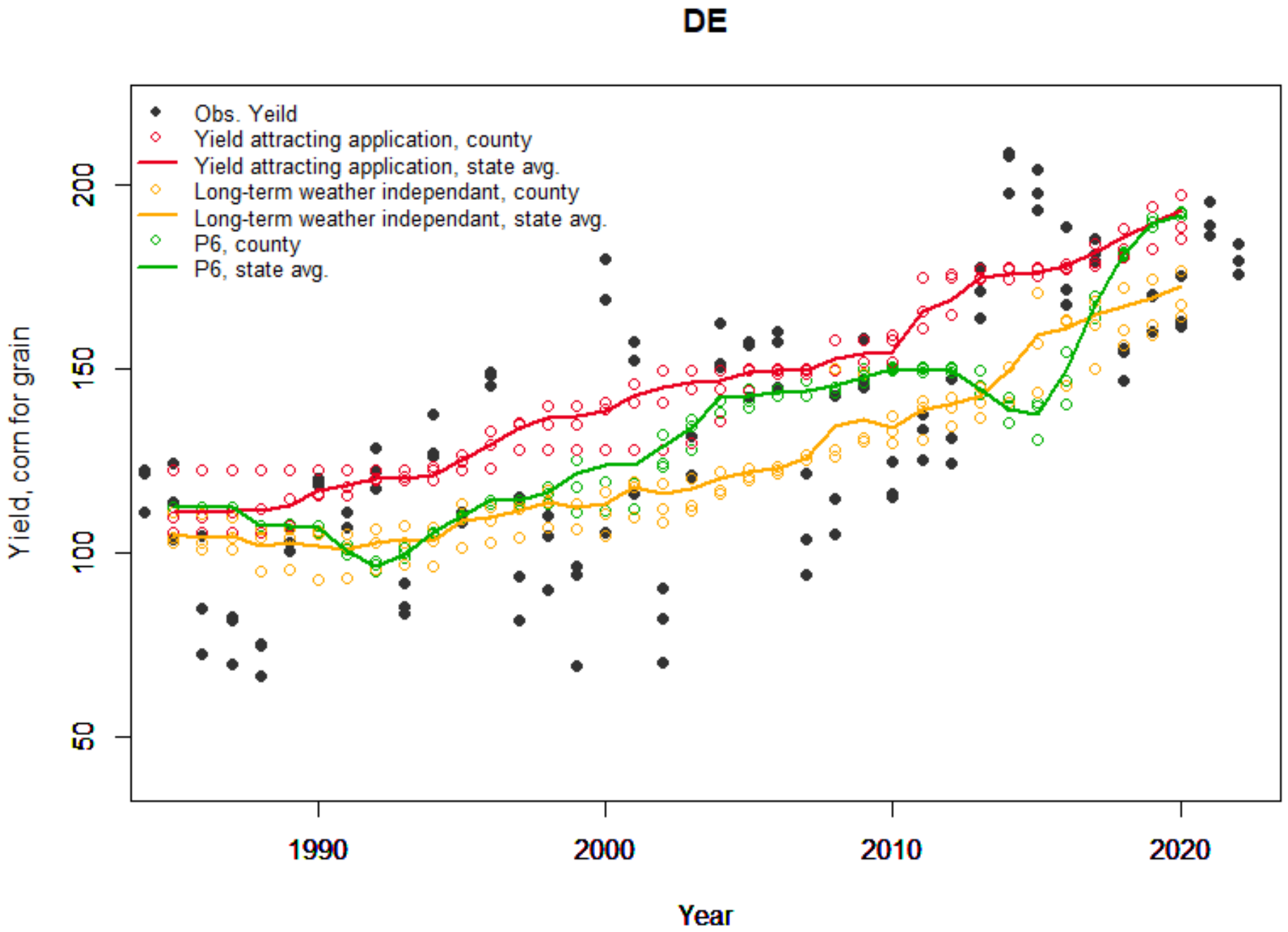
A look at the watershed scale

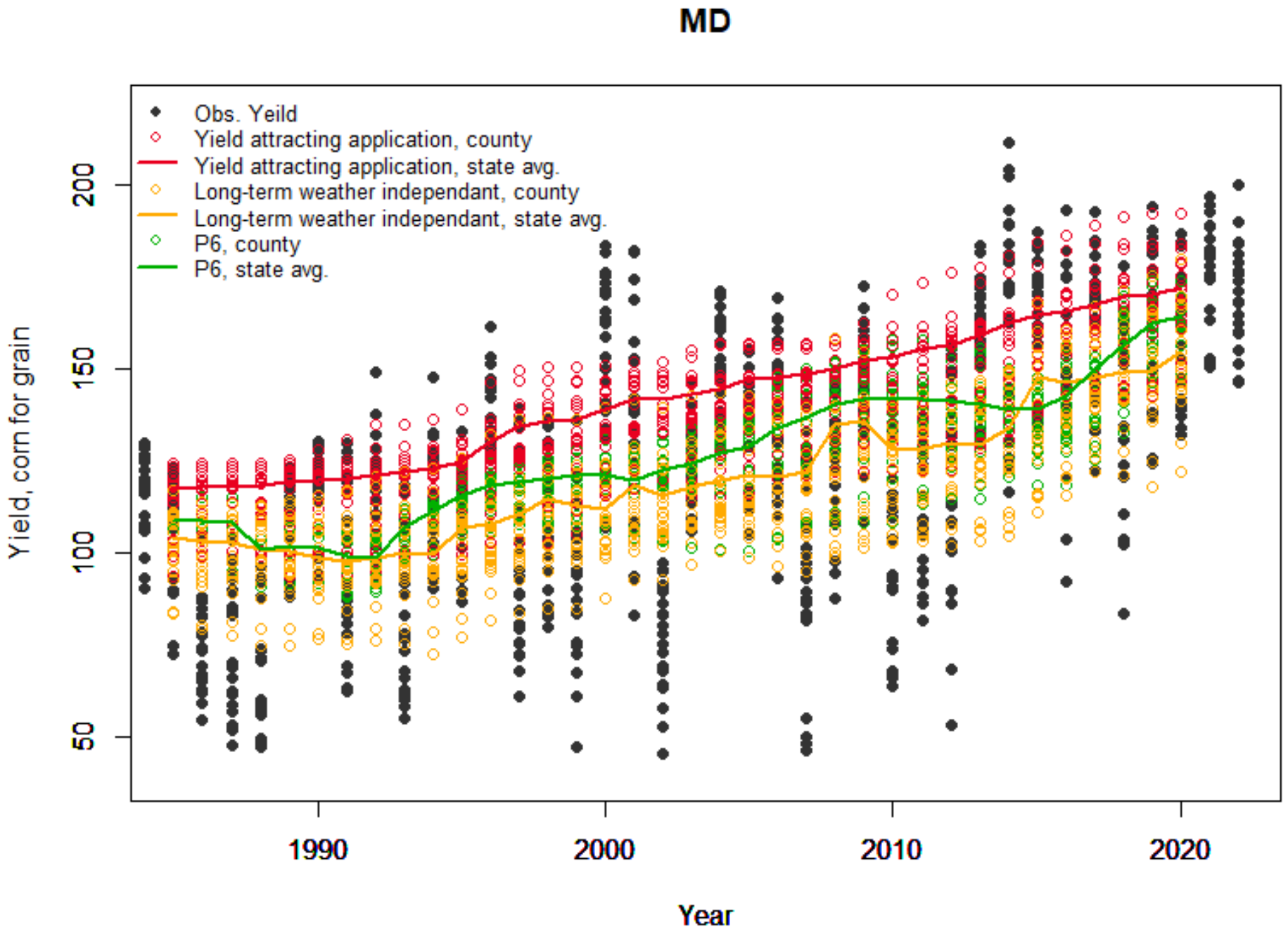
- Corn for grain
  - Expected application
  - Plant Available Nitrogen applied
- Watershed average

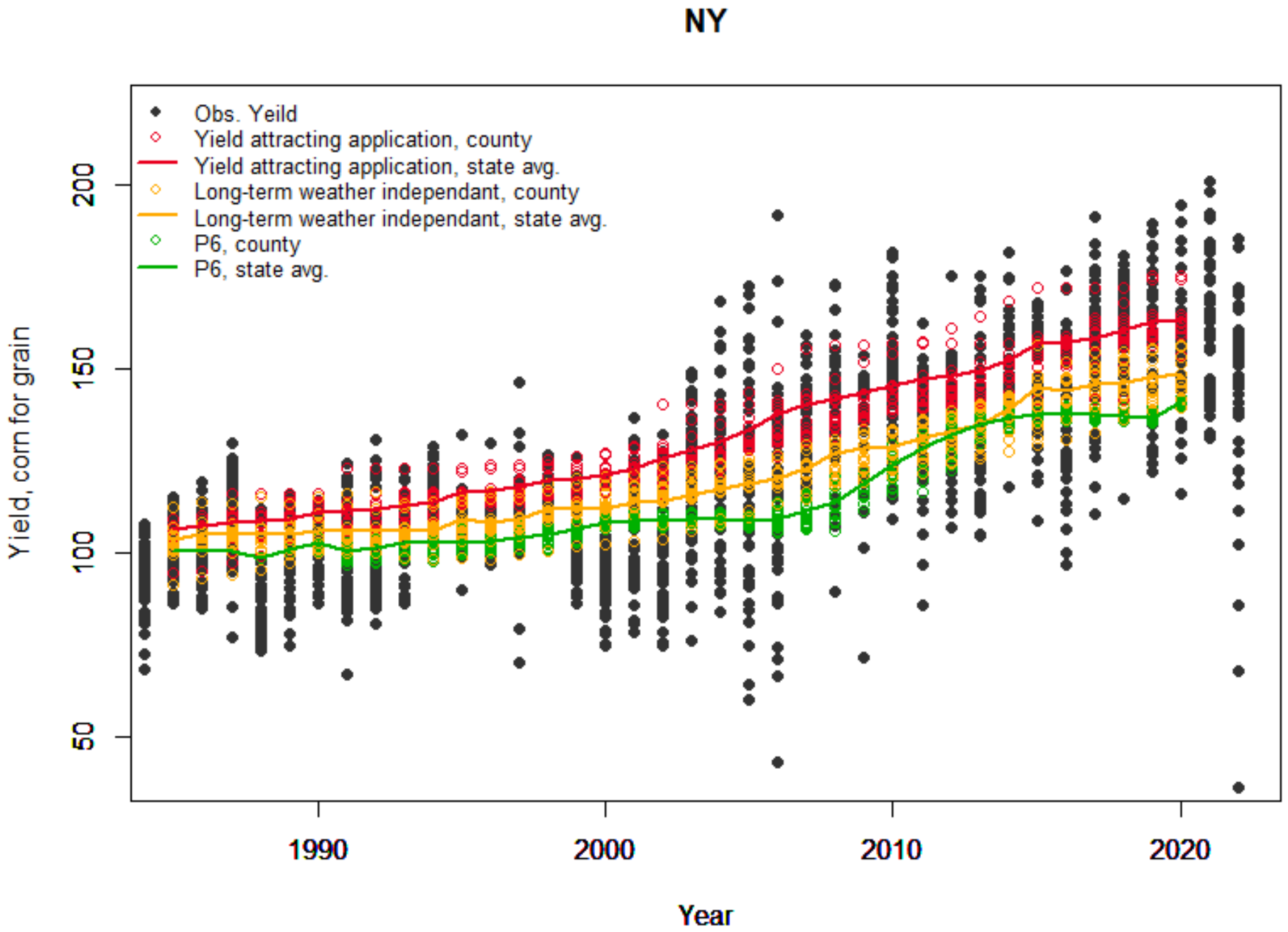

Watershed Average N required/acre
Nitrogen Required per acre
250
200
150
100
50
0
1990
2000
2010
2020
Year
Phase 6
Phase 7
LoadSource
Double Cropped Land
Full Season Soybeans
Grain with Manure
Grain without Manure
Leguminous Hay
Silage with Manure
Silage without Manure
Small Grains and Grains

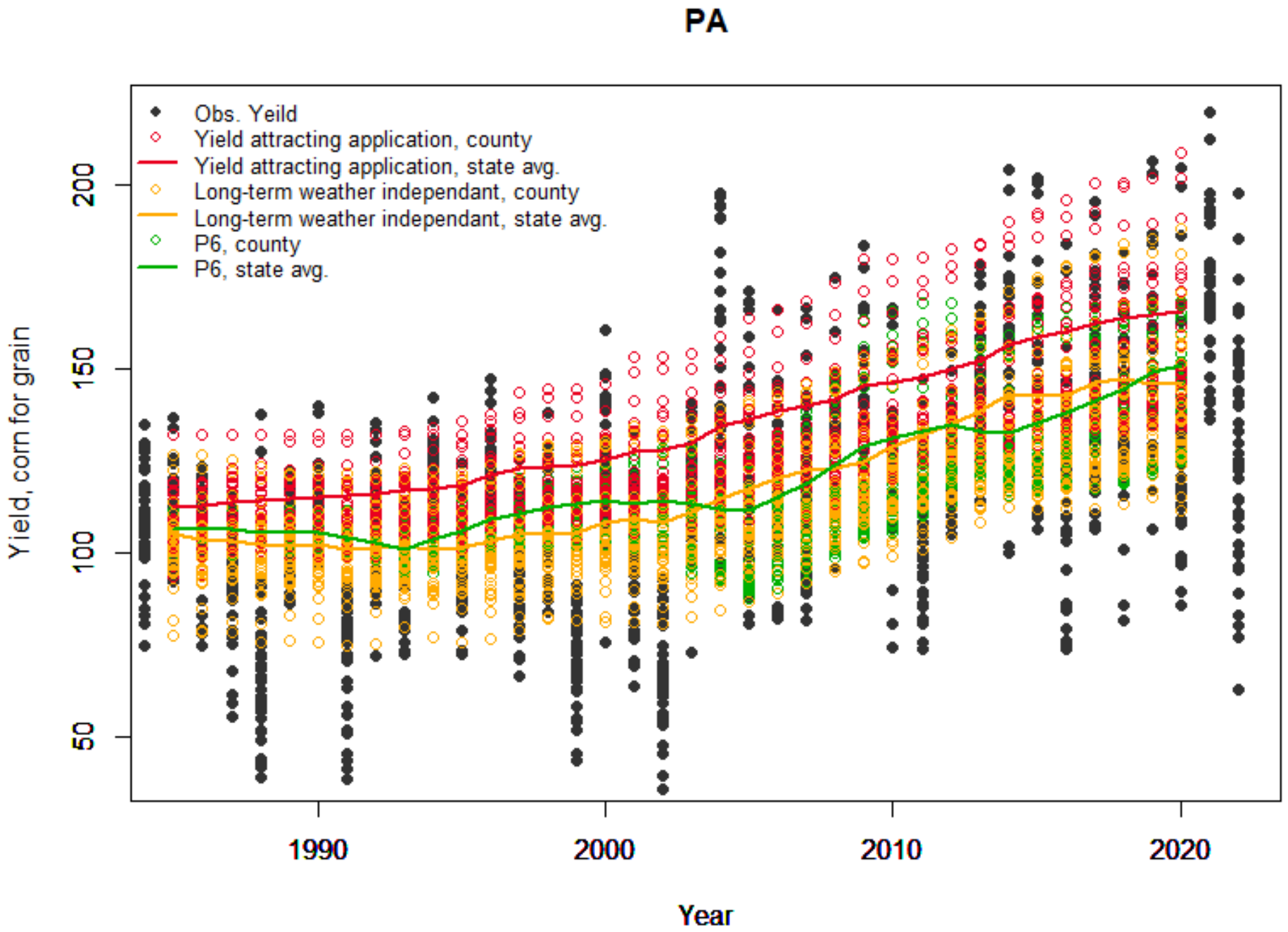

Watershed Average PAN/acre Applied
250
200
150
100
50
0
Pan/acre
1990
2000
2010
2020
Year
Phase 6
Phase 7
LoadSource
Double Cropped Land
Full Season Soybeans
Grain with Manure
Grain without Manure
Leguminous Hay
Silage with Manure
Silage without Manure
Small Grains and Grains

State Scale


DE
Obs. Yeild
Yield attracting application, county
Yield attracting application, state avg.
Long-term weather independant, county
Long-term weather independant, state avg.
P6, county
P6, state avg.
Yield, corn for grain
50
100
150
200
1990
2000
2010
2020
Year


MD
Obs. Yeild
Yield attracting application, county
Yield attracting application, state avg.
Long-term weather independant, county
Long-term weather independant, state avg.
P6, county
P6, state avg.
Yield, corn for grain
50
100
150
200
1990
2000
2010
2020
Year


NY
Obs. Yeild
Yield attracting application, county
Yield attracting application, state avg.
Long-term weather independant, county
Long-term weather independant, state avg.
P6, county
P6, state avg.
Yield, corn for grain
50
100
150
200
1990
2000
2010
2020
Year


PA
Obs. Yeild
Yield attracting application, county
Yield attracting application, state avg.
Long-term weather independant, county
Long-term weather independant, state avg.
P6, county
P6, state avg.
Yield, corn for grain
50
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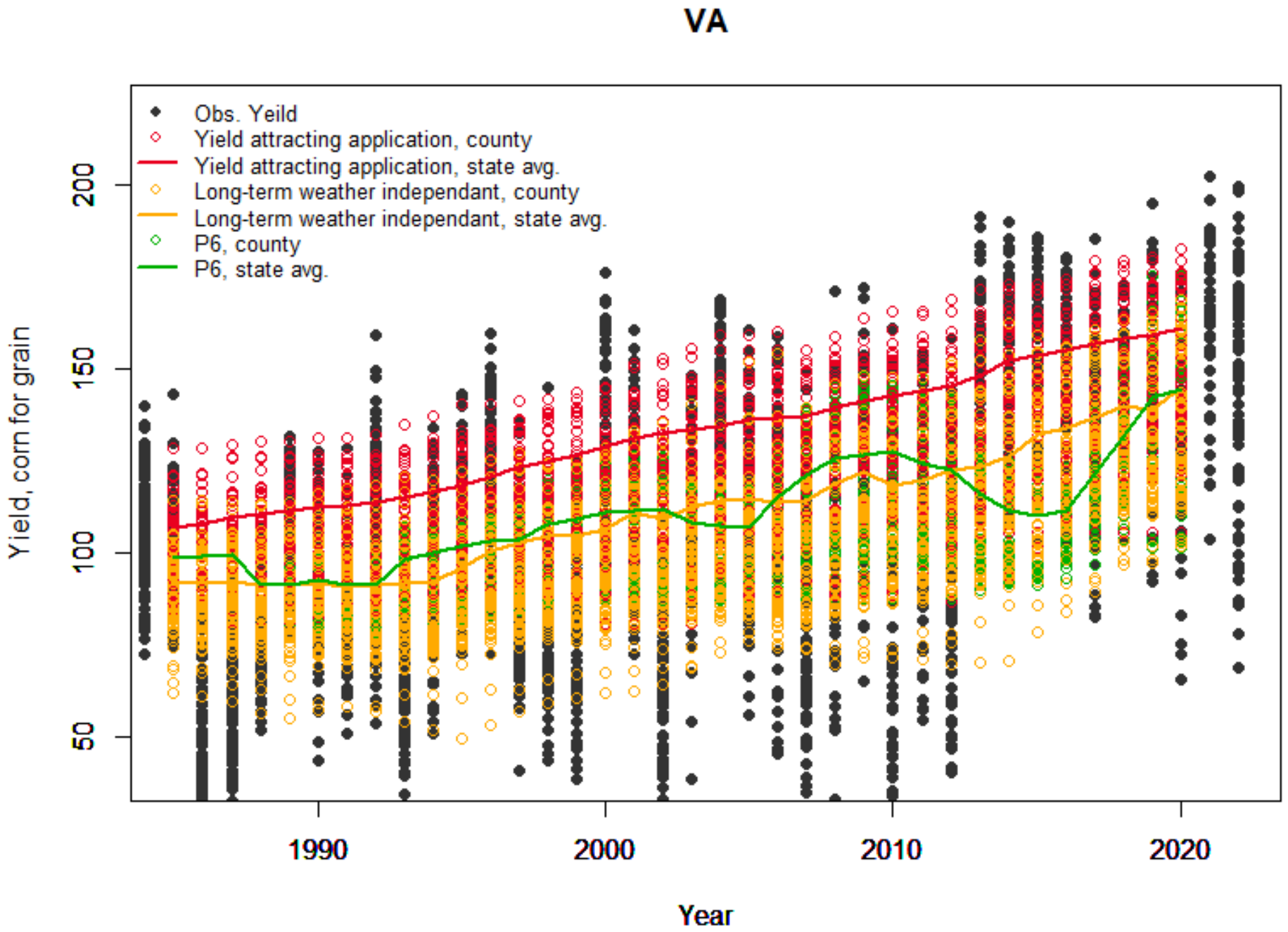
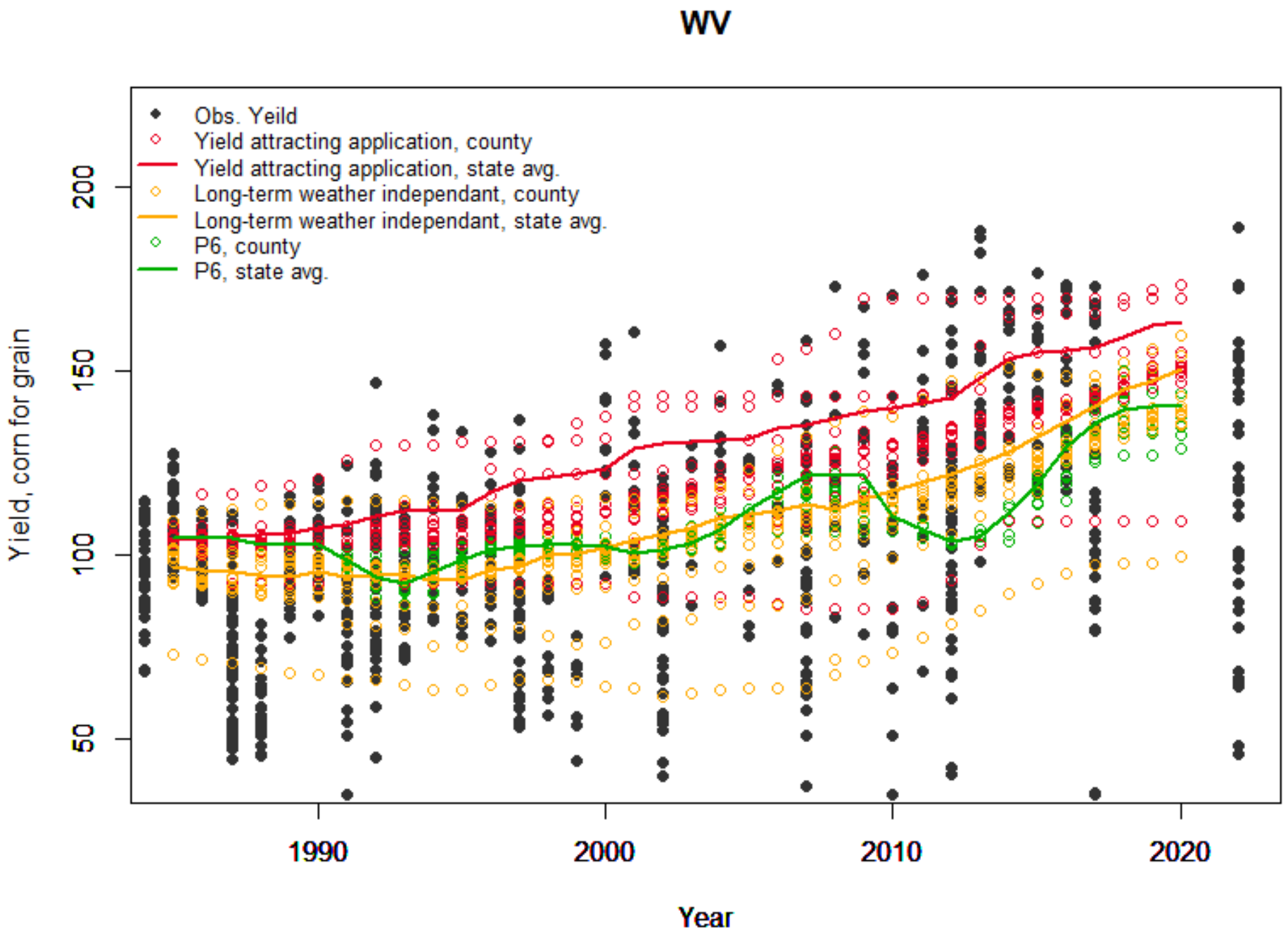
150
200
1990
2000
2010
2020
Year

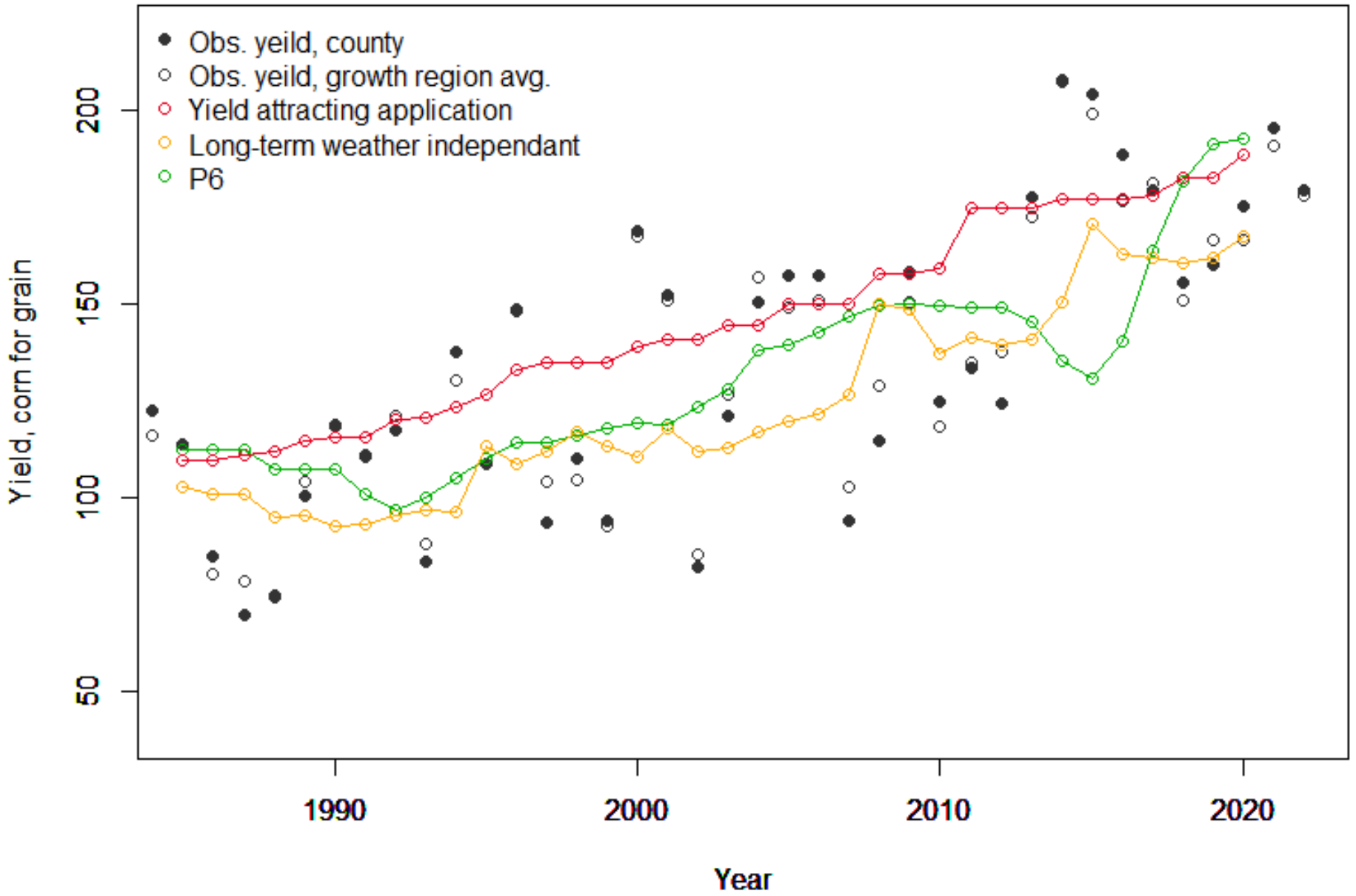

VA
Obs. Yeild
Yield attracting application, county
Yield attracting application, state avg.
Long-term weather independant, county
Long-term weather independant, state avg.
P6, county
P6, state avg.
Yield, corn for grain
50
100
150
200
1990
2000
2010
2020
Year


WV
Obs. Yeild
Yield attracting application, county
Yield attracting application, state avg.
Long-term weather independant, county
Long-term weather independant, state avg.
P6, county
P6, state avg.
Yield, corn for grain
50
100
150
200
1990
2000
2010
2020
Year

County Scale

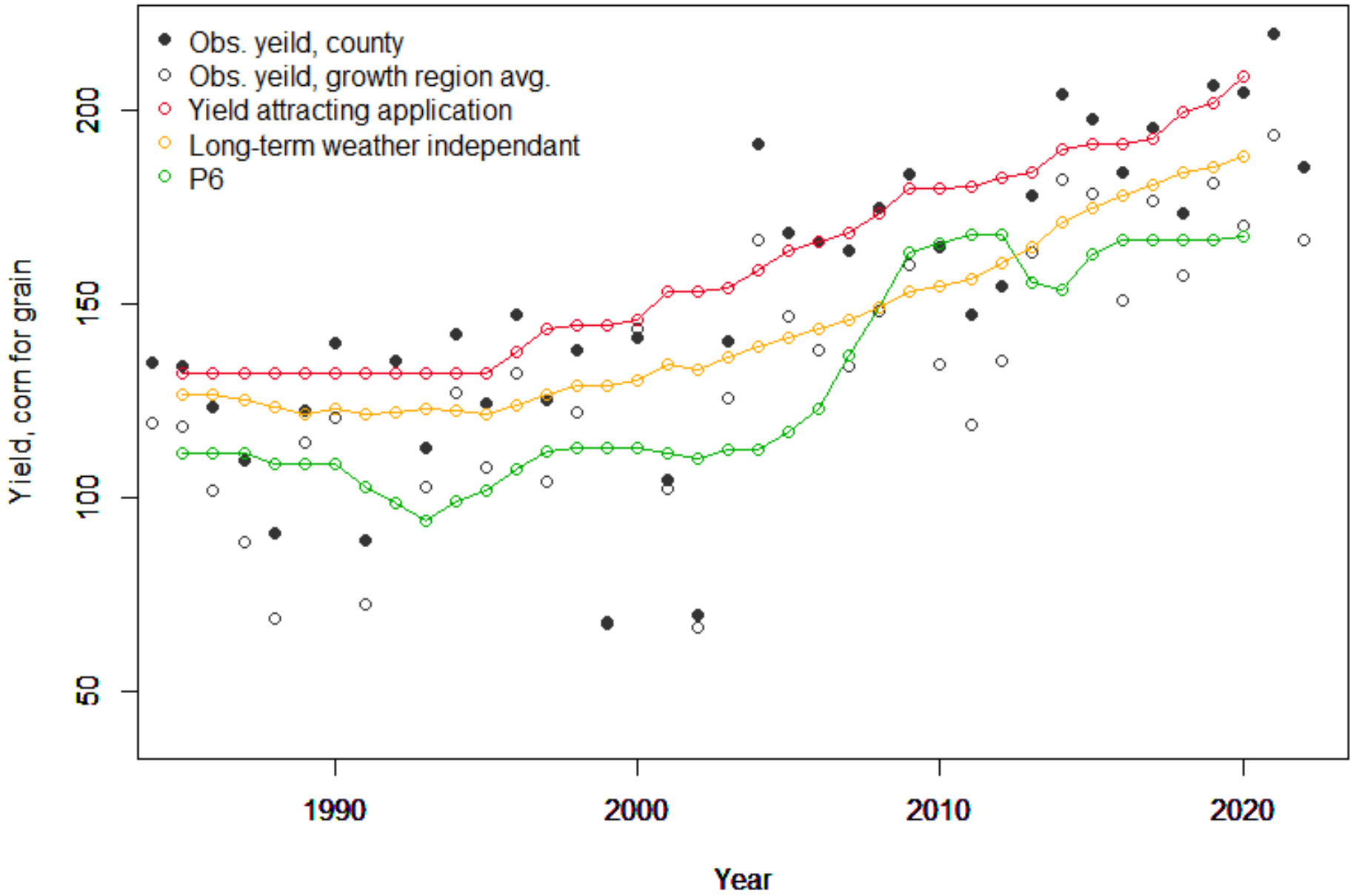
Kent county, DE

10001



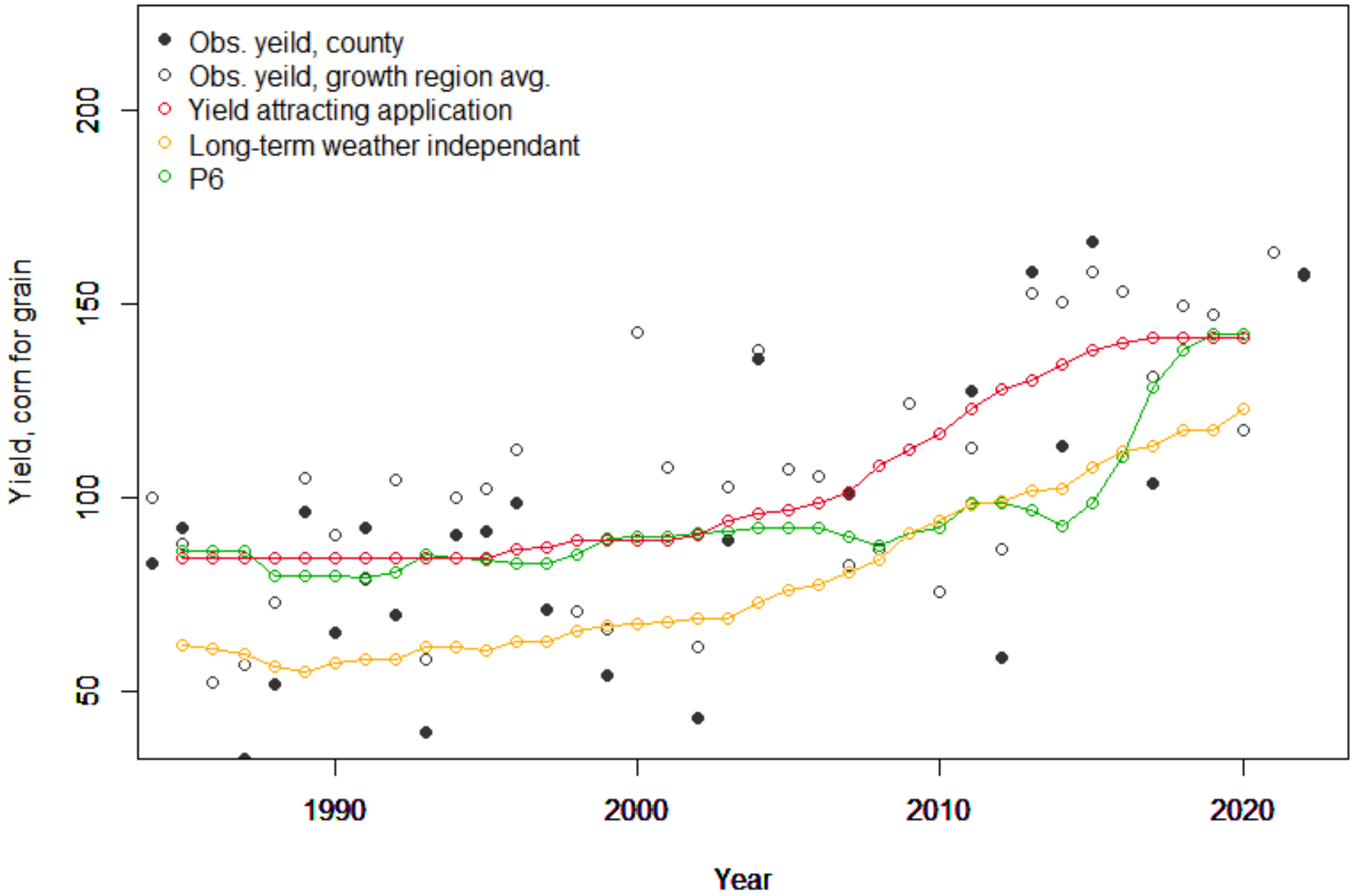
Lancaster county, PA

42071



Buckingham county, VA

51029



General takeaways:

- P7 method increases yields
- Better captures trends
  - Yield attracting application
    - (think best three of five)
  - Average yield
    - Used in Long-term Loads Calculations
- Reduced variability
- Remember, currently only 11 major crops

Questions?

Vote:

- ***We should adopt the new statistical methods for determining crop yield trends for all crops that have nutrient application goals per production per acre (true yield units).***

Consensus Continuum